Forests of West Virginia, U.S.A. and Shaanxi, China: a study in forest exploitation and recovery

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Abstract: A review of the period of unregulated exploitation of forests in the state of West Virginia (U.S.) and in Shaanxi Province, PRC was presented. Economic and ecological recovery from exploitation has been different in the two regions due to basic differences in nature of the forest and in the degree and persistence of exploitive pressures. After a century since unregulated exploitation, West Virginia forests are well on the road to management for sustainability and conservation. Shaanxi's recovery from overuse and unregulated exploitation is less certain; forests are still in the early phases of ecological recovery there. Full recovery to a period of sustainability will take a century or longer. Suggestions are made for measures needed to enhance the forest recovery.

Keywords: Forests; Shaanxi; West Virginia; Central China; Forest exploitation; Recovery

CLC number: S754 **Document code**: A **Article ID**: 1007-662X(2004)01-0049-06

Introduction

In the United States, West Virginia is called "The Mountain State." It is located entirely within the Appalachian mountain range in the eastern U.S.A. (80°42.2' E, 38°35.9' N). Geologists thought that millions of years ago the height of the Appalachians were 6 000-9 000 m (Zen *et al.* 1968). However, today the mountains of West Virginia are 600-1 500 m in elevation.

Shaanxi Province is located in the central China in the middle reaches of the Yellow River (105°29-111°15' E, 31°42' -39°35' N). The topography of Shaanxi is more varied than that of West Virginia of U.S.A.. The Loess Plateau, the Guanzhong plain, and the Qinling Mountain range give great diversity to the province. The Qinling Mountain range is unique in that it extends from east to west and causes a marked change from the temperate climate in the north of the range to the subtropical climate in its south. The highest peak in the range is 3 767 m.

In both West Virginia and Shaanxi, the forest resources have been heavily exploited. Exploitation is a word with different shades of meaning when it is used in conjunction with natural resources. It is often used to describe a regulated, planned process or activity that makes productive use of an item. In another sense, exploitation is used to describe unregulated, irresponsible activities that make use of an item unjustly and for one's own advantage. In this sense exploitation also suggests abuse. Though the physical situation between West Virginia and Shaanxi Province in China is quite different, the process of forest exploitation and progress of forest management and recovery is identical. We examine the forests of West Virginia and Shaanxi Province with the intent of depicting their exploitation and their potential for recovery to sustainable forests.

Early forests

Hicks (2000) examined notes from Bartram's 1751 explorations in the mountains of Pennsylvania (adjacent to West Virginia) and noted that the top ten species in frequency of mention in the explorer's notes were white and black oak (*Quercus spp.)*, white pine (*Pinus strobus* L.), chestnut (*Castanea dentata* (Marshall) Borkhausen), red spruce (*Picea rubens* Sargent), hickory (*Carya spp.*), sugar maple (*Acer saccharum* Marsh.), basswood (linden) (*Tilia americana* L.), pitch pine (*Pinus rigida* Mill.), elm (*Ulmus spp.*), and American beech (*Fagus grandifolia* Ehrh.). Twelve other species with less frequent occurrence were found in the notes.

Zhu (1989) concluded that about 3 000 years ago forests covered most of Shaanxi Province. Oaks such as *Q. variabilis* Blume, *Q. aliena* Blume *var actiserrata* Maxim., and *Q. liaotungengsis* Koidzumi dominated the mountains in Qinling as well as in the southern part of the Loess Plateau. Fir (*Abies fargesii* Franch.*)*, spruce (*Picea wilsonii* and *P. asperata*), and birch (*Betula albo-sinensis* Burkill and *B. utilis* D.Don*)* were distributed in the subalpine areas.

Due to exploitation and climate changes, the forest range in Shaanxi decreased and in general oak forests were re-

Foundation item: The project was sponsored by the Scientific Research Foundation for the Returned Overseas Chinese Scholars, State Education Ministry (2002-2004) and Shaanxi Provincial Foreign Expert Bureau (2003).
Biography: Jack E. Coster (1935-), male, professor of West Virginia University, Morgantown, West Virginia. U.S.A.
Received date: 2003-11-10
Responsible editor: Song Funan

placed by Chinese pine (*Pinus tabulaeformis* Carr.) and birch (*Betula albo-sinensis* Burkill and *B. utilis* D.Don). Secondary scrub and degraded forests now occur in large areas of the Qinling Mountains, and grass is dominant in the Loess Plateau. Similarly, Peng *et al.* (2002) concluded that the potential vegetation on the southern Loess Plateau of central Shaanxi was predominantly broad-leaved oak (*Quercus*) forests, grading into a forest-steppe with grass, oaks, and poplar (*Populus* spp.).

Exploitation

Until the 1850's, West Virginia's timber was relatively inaccessible to the markets. After then, railroads in the U.S. began to expand linking the rapidly growing cities of the East and the Midwest and providing access to the cities for the agricultural and forest products, upon which they depended. In West Virginia, the skyrocketing demand for wood that began in the late 19th century was a direct result of the booming industrial revolution economy that began after the American Civil War in 1865.

There are no statistics describing the amounts of lumber in the West Virginia forests when commercial cutting began. But the forests must have been remarkable in order to stimulate the large-scale exploitation that followed. Reports from tree cutters of that time (Clarkson 1964), told that red spruce trees 2-2.5 m in diameter at their base were common. Yellow-poplar (tulip-poplar) (*Liriodendron tulipifera* L.) often were 2-3 m in diameter and 40-45 m in height. Eastern hemlock (*Tsuga canadensis* (L.) Carriere) reached a diameter of 2 m. Northern red oak (*Q. rubra* L.) and white oak (*Q. alba* L.) were highly valued trees. A famous white oak was over 4.5 m in diameter.

By 1880, the commercial exploitation of West Virginia's forests was in full swing. Railroads not only transported the lumber to the cities of the nation, but they were also widely used in the forest to transport the logs to the sawmills for processing. Many logs were stored on riverbanks and "log drives" carried the logs downstream to sawmills.

Exploitation of central China's forests did not occur in the same manner as in West Virginia. Whereas West Virginia's forests were rapidly removed within a period of only 40 years, Shaanxi forests were removed more slowly. Neolithic cultures with settled villages and early agriculture were in Shaanxi 6 000 years ago. Impact on the forests by these early cultures was inevitable. Waley (1939) wrote that "forests in China were valued for more than just hunting: in about 300 B.C. the Chinese philosopher Mencius wrote of his concern about the deforestation of Bull Mountain owing to timber harvesting and overgrazing and its impact on stream flows". Population growth has been the underlying cause of forest degradation [1]. Fuelwood removal, logging, animal grazing, and agricultural conversion – occurring to varying degrees over long periods of time -- resulted from the population pressures. These problems extend into modern times.

Intensive logging of the remaining forests did occur, however, in the 1950s during China's "Great Leap Forward"[2]. Wood was primarily used for railway construction and as fuelwood for steel production. The forests of the Qinling and Bashan mountains were hard hit during this time. The forests were clearcut and by the 1990s only remnant stands were left on the high ridges of the mountains. The loss of forests during this brief period is not exactly documented for Shaanxi, but Wang (1997) notes that one-third to one-tenth of the growing stock was destroyed in other provinces during that time.

Forests recovery

The unregulated cutting almost completely destroyed the ancient forests of West Virginia. Lumber production peaked in 1910, and by 1920, after 40 years of unregulated cutting, lumber production had fallen to about 1/3 of the peak production of only ten years earlier (Zinn and Jones 1984).

The rapid logging of the forests left large amounts of debris from the logging. In short time, the debris became a significant fire hazard and large areas of the state were burned after logging was completed.

Erosion also became a problem. West Virginia is generally well watered, receiving 1 000–2 000 mm of precipitation each year. Without the forests to protect the soil and intercept runoff, some of the steep hills eroded. Floods occurred and property damage resulted.

There were no forestry laws to regulate activities at that time. Neither were there professional foresters to give advice. Private companies operated without forestry regulation.

In Shaanxi there was an abrupt decrease in the amount of forest cover, with reversion to grasses and shrubs (Zhang *et al.* 1989). Croplands increased, often at the cost of increased soil movement on steeper slopes (Lei 2003). Laws were not in place to regulate the activity. Wang (1997) estimated that by 1948 forest cover for Shaanxi had decreased to only 11% of the original forest area (1 999 million hm^2 from 18 208 million hm^2 at the beginning of the Neolithic age). Deforestation is the greatest source of economic losses among environmental degradation factors -- almost double the total losses arising from environmental pollution and degradation of natural resources combined and representing 12% of China's total national income in 1992 (Mao 1997).

West Virginia's climate is favorable to forest growth and re-growth. Exploitive logging removed the large trees and damaged or destroyed many others. Large numbers of young, immature trees remained in most areas. Most of the

[1] Shaanxi province has a population of about 34.4 million and a population density of 167 persons per km^2. West Virginia's present population is about 1.81 million persons, 29 persons per km^2.

[2] Richardson (1990) p. 96 also notes a national decline of the area of plantations in the period 1957-1964, attributing this to the liquidation of young plantations for fuelwood.

remaining small trees were broad-leaved hardwoods and many of these species reproduce vegetatively from roots and stumps. As in forests today, there also were seed sources from the relic trees as well as seed that was buried in the soil. These biological legacies were propagules for subsequent succession and formation of new stands.

Fuelwood from the forests was commonly used during the exploitive period, but not to a degree that it removed dead wood that was necessary for nutrient and organic matter replenishment of the soil. Thus, forest soils in West Virginia did not apparently suffer the severe degradation and deterioration that was experienced in Shaanxi where there were extensive gathering of tree parts and debris for fuelwood.

Recovery of the forests of Shaanxi has been much slower. In many cases, soil substrates are destroyed, resulting in water erosion. The flood disaster of 1998 on the Yangtze River gave strong impetus for strengthening national regulation of timber cutting. Unlike West Virginia, remnant trees were less common after cutting. Forest stands have been revisited many times after first cutting, and the understory, even seedlings, has been removed in some areas.

In some areas, coppice of oaks (*Q. variabilis, Q. aliena var. acutiserrata, Q. dentata* Thunb.) and poplar (*Populus davidiana* Dode) and coppice with standards are the predominant broad-leaved forests. Chinese pine (*P. tabulaeformis)* is beginning to occupy degraded sites previously occupied by oak.

A biomass accumulation model that describes the long-term re-development of a forest ecosystem following heavy disturbance or injury has been presented by Bormann and Likens (1979). They proposed four phases of forest re-development: reorganization, aggradation, transition, and steady state.

Reorganization is the early plant succession stage that begins with the destruction or removal of the vegetation of the forest. It is characterized by a net loss of biomass, rapid changes in the abundance and importance of species, and large changes in biogeochemistry and hydrology. In the northern hardwood forests of the northeastern U.S., this stage lasts from one to two decades after disturbance.

Aggradation is characterized by accumulation and building of biomass, slower changes in species dominance and occurrence, and increased nutrient storage in the biomass. Biomass accumulation shifts from net loss to net accumulation. This period of forest re-development lasts a century or longer and seems to be determined in large part by the natural longevity of the dominant tree species.

Transition is a period of variable length during which total biomass declines. The decline results as the old, even-aged trees established in the aggradation phase begin to die. The dead trees create patches in the forest canopy and young trees grow using the new availability of resources.

In the *steady state* phase, biomass of the forest oscillates about a mean level. These fluctuations result from random disturbances (natural senescence, fire, insects, weather, etc.) followed by re-growth. The old even-aged dominants of the aggrading phase come to be replaced by dominants of all ages. The forest becomes a mosaic of species and age classes. Because of the effects of human activities in forests, few forest stands are thought to attain the steady state stage.

Forty years of exploitation resulted in even-aged forest stand conditions over much of West Virginia's re-developing forests. The area of forestland has increased by about 2.8 million hm^2 from its low point in 1910. Today's forests are still relatively young (Fig. 1) with 54% of the stands in the 41-80 year age classes, reflecting their recent origins after the cutting of the past years. A high proportion (46%) of the standing tree biomass is in the large (>27.9 cm) diameter class (Fig. 2). Growth of the forests continues to accumulate wood volume until about the 70th year (Fig. 3). The total volume accumulation (Fig. 4) of the dominant 41-80 year age classes represents 59% of the total accumulation in the forest stands.

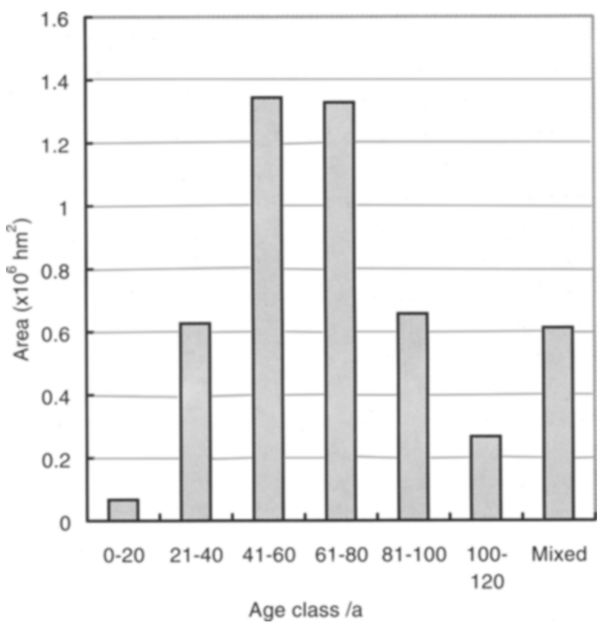

Fig. 1 Age class distribution of West Virginia forests.

Note: The data of Figs 1, 2, 3 and 4 are prepared using data from the Forest Inventory and Analysis Database of the U.S.D.A. Forest Service for West Virginia (1989). Forest Inventory and Analysis (FIA) is a continuing endeavor to determine the extent, condition, volume, growth, and depletions of timber on U.S. forestland. Each of the 50 State's are periodically surveyed using intensive forest sampling and analysis techniques.

In Shaanxi, forest succession is, for the most part in the earliest stages after clear cutting and intensive utilization. In the Qinling Mountains, where the best vegetation in Shaanxi is represented, forests are relatively young, as shown in Figs. 5 and 6. Grasses and shrubs have become

established, but in many cases removal of the trees has been so complete that extensive forest restoration will be necessary to place the areas back on a trajectory of forest succession. In the Loess Plateau, remnant forests are even less in area.

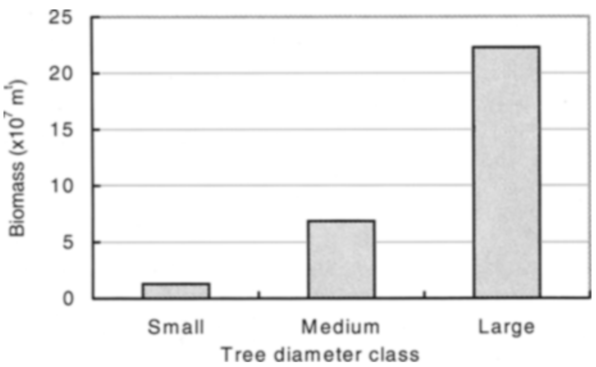

Fig. 2. Biomass (oven-dry basis) accumulation by tree size class of West Virginia forests. (Small: < 12.7 cm in diameter; Medium: >12.7<27.9 cm in diameter; Large: >27.9 cm in diameter for broad-leaved trees and >22. 9 cm in diameter for conifers. Diameters at 1.37 m above ground level.)

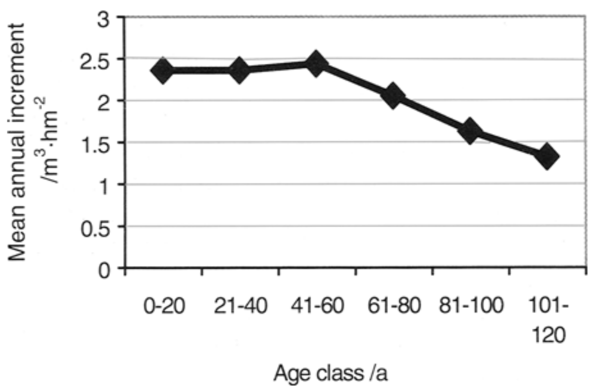

Fig. 3 Mean annual increment of age classes of West Virginia forests. (Each increment was determined at the mean age of the age class using volume of all live trees on timberland and area of timberland from the FIA Database)

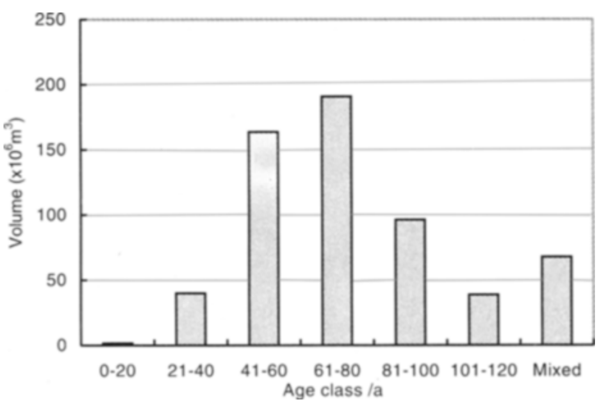

Fig. 4 Live volume of West Virginia forests by age class

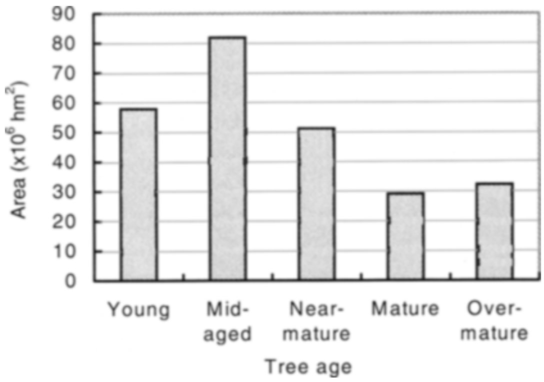

Fig. 5 Area of Forests in QinLing Mountains of Shaanxi Province

Note: The data of Figures 5 and 6 are from Shaanxi Provincial Institute of Forest Survey and Planning, 2000. Stands with an age-class at rotation of one class older than that of rotation are mature; stands with an age-class much older are over-mature and one age-class younger than mature stands is near-mature. For stands at age-classes younger than mature, one half of age-classes belong to mid-aged, the other half of them to young stands. For example, *Armandi* pine forest in Qinling has a rotation age-class of V (about 50-60 years old). Stands of age-class I to II is young, III is mid-aged, IV near mature, V-VI mature, and VII is over-mature.

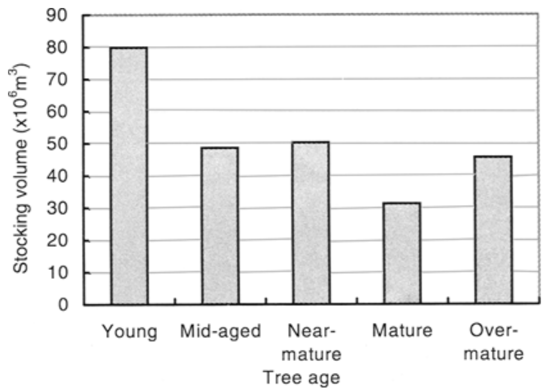

Fig. 6 Stocking volume of forests in the Qinling Mountains of Shaanxi Province

Recovery has been quite different for the two forest regions. Destruction of the old-growth West Virginia forest took only 40 years. Shaanxi forests have been more or less constantly exposed to destructive forces over hundreds of years. Some of those forces still exist at the beginning of the 21st century.

In West Virginia, forests now are predominantly in the mid- to late-aggradation phase of the Bormann-Likens model. Biomass is being rapidly accumulated in most forest stands. In Shaanxi, much of the area of the provincial forests is in reorganization and some in early stage of aggradation. For most of the Shaanxi forests, it will be perhaps two decades before most forests reach the aggradation phase and biomass accumulation begins to increase rapidly.

Future of the forests

Elliot (1996) pointed out that forest utilization at the national level generally goes through three stages: *unregulated exploitation, protective custody* and *conservation or stewardship.* As we have shown, West Virginia had a period of unregulated exploitation from 1880-1920. The 1930s began the custodial period when professional management was initiated and the forests began to recover. At the beginning of the 21st century, West Virginia is clearly in the conservation/stewardship stage of forest utilization characterized by management for sustainability.

Shaanxi has recently emerged from the period of unregulated exploitation. The Ministry of Forestry was established in the 1950s. In 1978 the "Three Norths" Protective Forest Project (northwest, northern, and northeast China) was implemented. Five natural forest regions in Shaanxi, in which the Qinling Mountains is included, have been designated as water source protection areas under the project (Zhang *et al.* 1989). In 1984 "The Forest Law of the People's Republic of China" was ratified. The Forest Law includes specifications on forest management and administration, forest protection, afforestation, and forest cutting. In 1998, China developed a new wide-ranging national policy, the Natural Forest Conservation Program (NFCP) (Zhang *et al.* 2000) to protect the remaining natural forest areas from further exploitation.

Unregulated exploitation of the forests of West Virginia and Shaanxi has been difficult and costly for the people of the two areas. There are several lessons for the future conservation and restoration of forest ecosystems in these areas:

A large forest estate can be devastated in a relatively short time by the unregulated assault of machinery and/or labor. Appropriate regulation is required to protect and maintain a sustainable forest estate.

Widespread destruction of the forests leads to undesirable, long-term ecological, economic, and social consequences. Fire, erosion, loss of jobs, destruction of wildlife and fisheries habitat, degradation of natural beauty, reduction of biological diversity, and deferred development of collateral income opportunities such as tourism are some of the consequences of the forest destruction.

Professional and scientific expertise must be available and given responsibility for care and management of the forests if they are to be placed on a trajectory of recovery to a state of sustainability.

In West Virginia, the condition of the forest estate bodes well for its future role in adding to the social and economic quality of life for West Virginians. The forests are growing at a rate over three times faster than the rate of removal by harvesting. The forest product industry is a leader in promoting scientific forest management. The recreation and tourism industry continues to expand as people find new outdoor activities in the forest. West Virginia's forests are well down the road of recovery.

The future role of forests in Shaanxi is yet in discussion. The area and stocking volume of natural forests, especially timber forests, continues to decline (State Forest Administration 2000). The NFCP of 1998 was formally initiated in 2000 and commercial cutting in all natural forests is suspended (Shaanxi Provincial Forest Administration 2001; Shaanxi Provincial Institute of Forestry Survey and Planning 2000). The nationwide crisis of wood availability within China has been recognized and steps are being taken to place the forests on a trajectory toward sustainability. China's wood demand is being met by imports.

We propose some renewed directions for forestry in central China:

Added emphasis to research that is directed to practical, field-level, forest management must be undertaken (Pretzsch 1987). The theory and practice of silviculture in central China may be traced back to methodologies developed in the former USSR. Those practices, based on management of large areas of old-growth or age-class forests, are not appropriate for central China conditions.

More attention should be paid to the use of native species for forest rehabilitation and priority given to mixed species forest management. Tree planting has been carried out over large areas in Shaanxi, but often with exotic species resulting in monoculture plantations.

We must adopt a long-term approach to planning for recovery of the forests. Surviving soil substrates and remnant trees species were important in West Virginia forest establishment, but recovery to the stage of sustainability still has taken about a century. However, both soil conditions and remnants of tree species have been disturbed more severely in Shaanxi forests. It is reasonable to estimate that the recovery of forests in central China will need much longer to reach comparable stages – optimistically it will be more than a century before forests may reach the level of sustainability.

The forest estates of Shaanxi and West Virginia, as with any region of the world, are valuable beyond the mere reckoning of the immediate products that they can produce. Wood production, fuelwood, medicines, and food come easily to the mind as values of the forest to humans. But beyond these obvious products of a forest are services or functions that result from a healthy ecosystem. These services, essential to human societies, include the purification of air and water, detoxification and decomposition of wastes, regulation of climate, regeneration of soil fertility, and production and maintenance of biodiversity. Healthy ecosystems perform these services "for free".

Products can be readily valued in their markets. Ecosystem services cannot be easily valued because they are not bought and sold in markets. In fact, they may be beyond value. As ecosystems degrade, so does their capacity to render both products and services. The importance of restoration and recovery of forest ecosystems goes to the heart of economic development, but it goes to the soul of

the health of societies.

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